RECEPTION TIMING DETECTION CIRCUIT OF CDMA RECEIVER AND DETECTION METHOD

BACKGROUND OF THE INVENTION

The present invention relates to a transmitter/receiver of a mobile communication system, especially an automobile phone/handy phone system (cellular system) using a direct spread code division multiple access (DS-CDMA) system and, more particularly, to a reception timing detection circuit of a receiver used in a base station.

Among many mobile communication systems, North America Standard system (TIA IS95) using a code division multiple access (CDMA) method is well known as the digital automobile phone/handy phone system (cellular system). The standard specification TIA/EIA/IS (INTERIM STANDARD) titled "Mobile Station—Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System PN-3421" was published on May, 1994 by TIA (Telecommunication Industry Association). The above specification describes the required operation of the mobile station in Chapter 6 of 95-A and the required operation of the base station in Chapter 7. This standard specification mainly aims at standardizing radio interface by specifying modulation method, signal format and the like. However the exact reception method is not specified in detail.

On the downlink channel from the base station to the mobile station, common pilot channel (PLCH) not data modulated is transmitted using relatively high power in addition to data modulated traffic channel (TCH) of a plurality of users. The mobile station is able to decide the optimum reception timing using the pilot channel. Therefore determination of the reception timing under a low Eb/No (the ratio of noise power per Hz to signal power per bit) condition is considered as a minor problem. In order to transmit the pilot channel using high power, the number of traffic channels through which data are actually transmitted has to be reduced. This leads to decrease the number of users per base station.

The uplink channel of IS-95-A from the mobile station to the base station employs a modulation method as a combination of modulation and 4 times direct spread using 64-ary orthogonal code and no common pilot channel thereon. Using the 64-ary orthogonal code allows for enhancing power per symbol compared with BPSK, QPSK and the like and prevents deterioration accompanied with coherent detection in spite of using a coherent detection. This results in, however, complicated reception method.

Main items of the IS-95-A are:

chip rate : 1.2288 Mcps;

bit rate : 9.6 kbps; and

spreading ratio of direct spread : 128 times.

The chip rate is relatively low and chip cycle is relatively longer than that of instantaneous variable amplitude of propagation delay. Therefore the reception characteristics are hardly susceptible to the effect of insufficient characteristics of the reception timing detection circuit. However, both bit rate and chip rate have to be accelerated at least 5 to 10 times higher for executing high-rate data communication as well as voice data. This problem has never been posed by the IS-95-A.

The conventional reception timing detection method (chip synchronization) is described in the document titled "Principle of Spread Spectrum Communication" written by

Andrew J. Viterbi, published on April, 1995, Chapter 3, pp. 39–66. The signal that has been spread with a spread code as pseudo random code is captured at two phases, initial Searching synchronous and tracking synchronous.

In the initial searching synchronous method, serial search is executed by sliding the reception timing by 1/2 chip interval until the correlation power exceeds a given threshold value as described in Chapter 3, section 4 of the above document.

In the tracking synchronous method, called as "early-late gate" or "delay lock loop" (DLL), the timing is finely adjusted by obtaining the correlation power at the timing ahead the reception delay time by Δt and the correlation power at the timing behind the reception delay time by Δt so as to make the difference zero.

A publication of JP-A 34794/1992 discloses the method in which the above-described initial searching synchronous and tracking synchronous methods are improved, the circuit is shared and the function for tracking the multiple propagation path is added. The basic operation of this method is identical to that of the reference as described above, failing to solve the task of the IS-95-A.

The code division multiple access (CDMA) method realizes communication that satisfies quality requirement under a very low Eb/No condition by employing such technologies as path diversity using multiple path propagation (RAKE), macro diversity for connecting a plurality of base stations around the cell boundary (soft hand off), error correction code exhibiting high encoding gain, transmission power control and the like.

The CDMA method requires strict synchronization of chip timing for reception. If the number of diversity branch (the number of path) increases, the correct path timing has to be detected under a very low Eb/No condition per path.

In the conventional method for obtaining a correlation value by sliding a correlation timing and detecting the timing when the correlation power becomes maximum, especially when the noise power is higher than the signal power, failure in peak detection frequently occurs owing to noise. This is the first problem of the conventional art.

The power of the correlation per symbol is obtained by summing the signal power and the noise power. When the correlation value power is averaged over a plurality of symbols, dispersion of the measured correlation values is decreased. However, the original correlation peak is too small to detect the right peak. This is the first reason.

In the conventional method, the reception signal does not always coincide with the one that has been used for calculating the correlation value with different delays. In case the reception level varies to the greatest degree owing to fading, the peak of the sliding correlation value does not always coincide with the peak of the right delay profile. This is the second reason.

In order to obtain the peak of the delay profile accurately, the conventional method requires a large amount of correlation operation. This is the second problem that should be solved.

The conventional method obtains power of the correlation values and further the average value of the obtained power. As the process for obtaining the power contains a square operation (non-linear operation), linearity is no longer retained, allowing for no interpolation of the delay profile. Therefore, the correlation value has to be calculated by changing the delay time with the intended accuracy.

As the third problem, the conventional method requires a large sized hardware.

More specifically, two types of circuits, initial searching synchronization circuit (search circuit) and tracking syn-